BREAKTHROUGHS

UC Berkeley Rausser College of Natural Resources

SPRING 2025

Our Global Reach

Rausser College's international exchanges and impacts around the world

UC Berkeley
Rausser College of
Natural Resources

DEAN
David D. Ackerly

EDITOR
Julie Gipple

ASSOCIATE EDITOR
Mathew Burciaga

CREATIVE DIRECTOR
Arnaud Ghelfi

COPY EDITOR
Laura Deck

CONTRIBUTING WRITERS
Brad Balukjian
Mathew Burciaga
Janet Byron
Caroline Champlin
Julie Gipple
Kara Manke
Tomas Weber

CONTRIBUTING PHOTOGRAPHER
Mathew Burciaga

CONTRIBUTING ILLUSTRATOR
Valerie Chiang

DESIGN & PRODUCTION
l'atelier starno, www.starno.com

ONLINE DIRECTOR
Joseph Bunik

ONLINE PRODUCTION
Biviana Herrera
Magaly Santos

©2025 by the Regents of the University of California. All rights reserved.
Breakthroughs is a registered trademark.

UPDATE YOUR ADDRESS
breakthroughs@berkeley.edu

Breakthroughs
Rausser College
of Natural Resources
University of California, Berkeley
101 Giannini Hall, #3100
Berkeley, CA 94720-3100

nature.berkeley.edu/breakthroughs

CONNECT WITH US
facebook.com/raussercollege
@NatureAtCal
nature.berkeley.edu/linkedin
@NatureAtCal

LETTER FROM THE DEAN

Rausser College's commitment to addressing pressing environmental and societal challenges extends far beyond the Bay Area. Our international students and researchers and robust study abroad opportunities create a rich learning environment, and our research initiatives and collaborations transcend boundaries.

This issue of *Breakthroughs* exemplifies our College's global reach. We feature scientists developing disease-resistant cacao plants that could safeguard the world's supply of chocolate. We profile a professor who's dedicated her career to understanding the people and ecosystems of Indonesia. And we highlight a global network of collaborators who are producing long-term, continuous datasets to help climate scientists assess ecosystem carbon sequestration and evaluate climate solutions like wetland restoration and forest regeneration.

These pages also spotlight students supported by a donor-funded initiative for international students, as well as an alum of the Beahrs Environmental Leadership Program, which has trained more than 814 climate professionals from over 115 countries to date. And we celebrate the California-China Climate Institute's inaugural five years. The Institute's emphasis on subnational climate actions between states and Chinese provinces will be more important than ever in coming years.

Closer to home, we were deeply saddened by the destruction from the wildfires in Southern California; they are a sobering reminder of the effects of climate change and the urgent need for effective wildfire management strategies. We know that many in our community have faced tremendous losses and our thoughts are with you.

This academic year we've welcomed Rich Lyons—a Berkeley alum, economist, and former dean of the Haas School of Business—as the 12th Chancellor of UC Berkeley. We're working with him to ensure the continued success of our community and to support our ongoing impact across California, the nation, and the world.

I hope you'll find these stories inspiring, and I welcome your feedback at dackerly@berkeley.edu.

David D. Ackerly

BREAKTHROUGHS

How to Decipher a Forest

A career devoted to the people and ecosystems of Indonesia.

Page 8

A World of Climate Data

A global network measuring the breathing of the biosphere.

Page 14

(Not) The End of Chocolate

Working to safeguard the planet's supply of cacao from disease.

Page 18

ONLINE
Stay up to date with Rausser College news, awards, and programs on our website.

California's gray wolf comeback

After nearly a century of absence from California, gray wolves have returned, and Rausser College of Natural Resources researchers are advancing comprehension of the social and ecological factors that shape wolf populations and inform management decisions.

Gray wolves disappeared from California in the 1920s, and the next documented sighting wasn't until 2011 when individual wolves were noted entering from Oregon. As of early 2025, the California Department of Fish and Wildlife (CDFW) has reported at least nine wolf packs across the state.

In partnership with CDFW and with additional support from the National Geographic Society, the California Wolf Project (CAWP) brings together scientists, wildlife managers, and conservation communicators working to understand the ecology and wolf-human interactions of the recolonizing population. Starting with a field season last summer, the group has been gathering data on wolf spatial ecology, diet, predator-prey dynamics, and recolonization within California, while contributing to conflict reduction strategies for rural communities and agricultural producers.

California's wolf packs utilize large expanses of habitat compared to those in other areas in the western US, presenting challenges for monitoring the population and

Old vine, saving wine?

Since first being reported in Anaheim, California, in the 1880s, Pierce's disease of the grapevine has spread across the state, the US, and Europe. Triggered by the bacterium *Xylella fastidiosa*, it clogs tubes called xylem that transport water and nutrients, leading to plant death. Recent estimates suggest the disease causes over $100 million in lost revenue and prevention-related costs in California each year.

In a study published last December, Rausser College researchers identified a 120-year-old grapevine cutting at UC Davis that still contained traces of *X. fastidiosa* DNA from the early 1900s. By comparing that genome to more than 330 contemporary strains of *X. fastidiosa*, they reconstructed the history of how the pathogen first arrived in California.

Scientists had long assumed that *X. fastidiosa* was introduced to California in the 1880s, when many species of grapes were brought to the state to establish vineyards. But the study's genomic data suggests that the pathogen actually arrived in the US nearly 150 years earlier, around 1740, from Central America. The data further suggests that the disease in California arose from not one but at least three separate introductions of the pathogen.

"This occurred over 250 years ago but is still relevant to understanding the global spread of plant pathogens today," said **Monica Donegan**, a graduate student in the Department of Environmental Science, Policy, and Management (ESPM) who co-authored the study with postdoctoral scholar **Alexandra Kahn**, PhD '23 ESPM. "Assumptions about the routes and

A grapevine infected with Pierce's Disease

Malia Byrtus (wolf); Monica Donegan (grapevine)

questions regarding the availability of prey. The state and many landowners are mounting a variety of livestock protection and conflict reduction efforts and learning new lessons about their efficacy. Co-led by Professors **Arthur Middleton** and **Justin Brashares**, CAWP complements the state's efforts with rigorous research and an outreach strategy for collaborating with local communities affected by wolf activity.

Left: A newly collared wolf from the Beyem Seyo pack after being released close to where she was captured by CDFW helicopter teams in January 2025.

Above: California Wolf Project postdoctoral researcher Kaggie Orrick examines an elk carcass during fieldwork.

timing of pathogen introduction can impact things like international trade policies and quarantines for plant pathogens."

The fact that there were likely three separate introductions of *X. fastidiosa* suggests that multiple, genetically distinct, pathogen populations may exist in California. Like different variants of SARS-CoV-2, they may cause similar symptoms but respond differently to stressors like climate change. "These biological differences, even if small, can be meaningful when it comes to disease management," said Professor **Rodrigo Almeida**, the study's senior author.

— *Kara Manke*

A 120-year old grapevine cutting in archives of the UC Davis Center for Plant Diversity that still contained traces of *X. fastidiosa* DNA.

Malia Byrtus (researcher); UC Davis (vine); Courtesy of faculty (headshots)

Newsmakers

"It would be a speed bump in the road, but if the US goes all electric in 2090 rather than 2050...a lot of carbon would be emitted in that time."

— Agricultural and Resource Economics professor **Joe Shapiro** spoke with *The Guardian* in February about potential impacts if the Biden-era electric vehicle tax credit were to be overturned by the Trump administration. A study he co-authored shows that while a growing number of people would still go electric, the total number of EV cars sold would shrink by more than 300,000 a year compared to if the incentive stayed in place.

"Literally off the charts."

— Environmental Science, Policy, and Management professor **John Battles** spoke to *CalMatters* in January, explaining how the vapor pressure deficit—a combination of high air temperature and low relative humidity—greatly exceeded norms and helped fuel devastating wildfires in Southern California that month.

"The FAIR Plan just wasn't designed to be a permanent solution for a large swath of the market."

— In a January episode of NPR's *Planet Money,* Agricultural and Resource Economics professor **Meredith Fowlie** expressed concern that California homeowners enrolled in the FAIR Plan, the state's home insurance provider of last resort, would wind up stuck in the program due to private insurers refusing to issue policies in fire-prone areas.

Picture Perfect

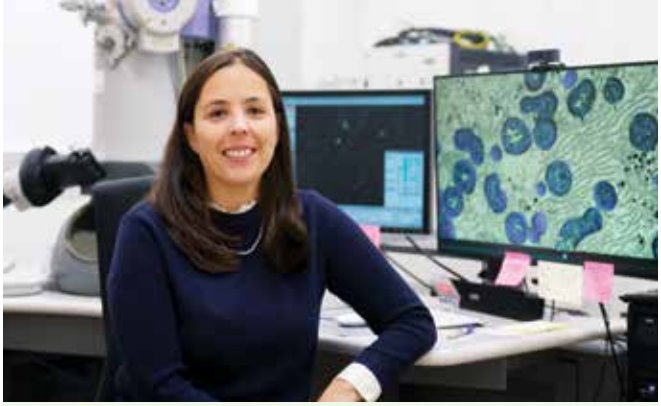
In January, 2024 grad **Vishal Subramanyan** and California Academy of Sciences student interns Prakrit Jain and Harper Forbes released the very first photos and video of the Mount Lyell shrew, the only known mammal in California that had never been photographed alive. The researchers were able to document the elusive mammal—it was first identified in 1902—during an expedition in the Eastern Sierra last November. News and photos of the shrew were covered in many notable media outlets including CNN, *The Guardian*, CBS News, and NPR.

The Ticker

Nine Rausser College faculty were among the **most cited individuals in their fields** in 2024, according to a report from analytics firm Clarivate. Their studies are in the top 1% of scholarly citations worldwide.

Margaret Torn, an adjunct professor in the Energy and Resources Group, was elected a member of the National Academy of Engineering in February.

Professor Emerit **Keith Gilless** and a team of collaborators are creating models of emergency response infrastructure in the Bay Area to simulate wildfire evacuations under different scenarios, identify potential weaknesses, and educate the public about wildfire readiness.



Why I Do Science

BY ANA PAULA ARRUDA

I was exposed to science very early through my father, a scientist and professor of plant genetics in Brazil. I'd spend school vacations in his lab, observing and conducting small experiments. These experiences instilled in me a deep appreciation for the scientific method and the thrill of uncovering the unknown.

My research seeks to understand the dynamic relationship between cellular architecture and metabolic regulation and how those relate to complex metabolic diseases like diabetes and fatty liver disease.

Our lab uses high-resolution imaging to visualize organelle structures within cells and tissues; these advanced technologies allow us to see cellular structures in ways that were previously unimaginable. At the same time, studying metabolism and metabolic diseases presents significant challenges, since it involves highly complex and interconnected biological pathways with multiple redundant mechanisms, making it difficult to disentangle cause-and-effect relationships. But for me, this complexity is also what makes metabolism research so exciting.

Science and innovation are key drivers of progress. We witnessed this during the COVID-19 pandemic, when decades of basic research proved essential in developing vaccines and treatments. We are also seeing rapid advancements in artificial intelligence, which have the potential to revolutionize research, medicine, and many other fields. In my specific area, the development of GLP-1R drugs—which correct blood sugar and promote weight loss—have had an important impact on the obesity and type 2 diabetes epidemic, demonstrating how scientific discoveries can translate into real-world solutions for major public health challenges.

Now more than ever, science is essential for addressing complex global issues—from health and disease to climate change and technology. Investing in scientific research is not just about innovation; it's about shaping a healthier and more sustainable future.

Ana Paula Arruda is an assistant professor in the Department of Nutritional Sciences & Toxicology.

Vishal Subramanyan, Prakrit Jain, and Harper Forbes (shrew); Mathew Burciaga (Arruda)

Capitol Connections

In February, Dean **David Ackerly** visited Washington, DC, as UC Berkeley's representative at the annual meeting of the Council for Agricultural Research, Extension, and Teaching (CARET), an organization created by the Association of Public and Land-grant Universities to coordinate engagement with USDA and the federal government. UC's CARET delegation spent three days on Capitol Hill meeting with staff from more than two dozen California congressional offices. The delegation shared stories of how federal funding makes a difference on the ground in California, especially the capacity funds embedded in the Farm Bill for the Agricultural Experiment Stations (including Rausser College) and UC Cooperative Extension. "We had productive and bipartisan discussions about water, agriculture, forestry, wildfire, and related topics, which impact every corner of our state," said Ackerly.

Left to right: Gina Daly (UC Berkeley Federal Government Relations), Sam Dorsey (staff to Rep. Doug LaMalfa), Connie Stewart (CARET delegate), Grace Rickman (staff to Rep. LaMalfa), Brent Hales (Associate Vice President, UC Division of Agriculture and Natural Resources), David Ackerly, Rick Satomi (UC Cooperative Extension)

By the Numbers:

Our International Community

1 *in* 5

graduate students are international students

49

Number of countries that Rausser College international students call home

49%

of postdoctoral researchers in Rausser College in 2024 are from another country

The top countries they came from are

China, India, South Korea, *and* Italy

***Nearly* 25%**

of all Rausser College undergraduates study abroad

The most popular majors for international undergrads are

Environmental Sciences

— and —

Environmental Economics and Policy

Top 5 countries where Rausser College alums living abroad reside are

United Kingdom, Canada, China, Australia, *and* France

Connect with other Rausser College of Natural Resources alums in our LinkedIn group.

Brian Kastl

Alejandra Echeverri

Christopher Schell

National Geographic Explorers

BY MATHEW BURCIAGA

Since 1888, more than 15,000 scientists, storytellers, and educators—including many from UC Berkeley—have received grants from the National Geographic Society (NGS), one of the largest scientific and educational organizations in the world. Each grantee is dubbed an Explorer, a recognition of how their work furthers the Society's mission of illuminating and protecting our world's wonders.

"UC Berkeley and NGS both understand the urgency of addressing global challenges relating to climate change and biodiversity loss," said **Justin Brashares**, a professor in the Department of Environmental Science, Policy, and Management (ESPM) and member of the Society's Committee on Research and Exploration. "These are areas in which many Rausser College of Natural Resources researchers are leading the way."

Here, we highlight a handful of the Rausser College students, faculty, and alums affiliated with the Society.

Damian Elias

Professor Elias received a grant to study peacock spider evolution and behavior in Australia in 2016. His research helped document the genus' *(Maratus)* elaborate courtship rituals, which involve a coordinated song-and-dance display using a colorful set of abdominal flaps and leg tufts.

Brian Kastl

Kastl, PhD '23 ESPM, was named an Explorer in 2018 while conducting research on the seaward migration of juvenile coho salmon. His studies of Northern California's Russian River highlighted how drought and climate change have shrunk the migration window of salmon, threatening the species' population.

Sean Perez (Kastl); Loren Elliott (Schell); Fernanda Pineda (Echeverri)

Becca Brunner

Brunner, PhD '22 ESPM, conducted fieldwork across Ecuador for part of her PhD, studying how human disturbance and habitat degradation affect local frog populations. Since becoming an Explorer in 2019, Brunner has described two species of glass frogs near active mining sites and documented the first case of a glass frog using both acoustic and visual signals to attract a mate—an adaptation that allows them to communicate within their loud waterfall habitat.

Kendall Calhoun

Calhoun, PhD '23 ESPM, received Society support in 2020 for research focused on understanding how ecological disturbances like wildfire impact the resilience of California's wildlife communities. He conducted fieldwork at the UC Hopland Research and Extension Center, a 5,358-acre living laboratory in Northern California that burned during the Mendocino Complex Fire in 2018.

Alejandra Echeverri

Now an assistant professor in ESPM, Echeverri received a Society grant in 2016 in support of her doctoral fieldwork in Costa Rica, which was focused on the cultural value of birds. She studied the characteristics that make birds more prone to be liked or disliked by people, finding that people prefer forest-affiliated birds.

Christopher Schell

An urban ecologist and ESPM assistant professor, Schell studies how urban attributes and social inequities affect wildlife and people in cities. His work, which is supported by the Society's Wayfinder Award, combines wildlife cameras with movement ecology techniques to investigate how human activities, food subsidies, and disease prevalence impact coyote behavior and conflicts across the Bay Area.

Arthur Middleton

Professor Middleton's relationship with National Geographic stretches back to 2013, when the Society awarded him a grant to study the relationship between pumas and vicuñas in the Argentinian Andes. His research on large-scale conservation in the Greater Yellowstone Ecosystem of Wyoming, Montana, and Idaho was supported by a 2017 fellowship. He is currently working with the Society on a three-year study of wolves in California (see page 2).

Sam Maher

Maher, a PhD candidate in the lab of Professor Arthur Middleton, received a grant to study the collection of shed antlers in the Greater Yellowstone Ecosystem in 2022. The collection of scavenged wildlife resources like antlers, which has grown more popular, has the potential to influence wildlife behavior, but these resources are understudied relative to their conservation significance.

Later this year, UC Berkeley and NGS will launch a first-of-its-kind collaboration to identify new explorers in North America whose research or conservation projects focus on keystone species that are ecologically, economically, and/or culturally important.

Sam Maher

Arthur Middleton

Becca Brunner

Amelia Hiatt (Maher); Joe Riis (Middleton); Courtesy of Becca Brunner

How to Decipher a Forest

Nancy Peluso has spent her career analyzing entanglements between human and natural worlds.

By Tomas Weber

Nancy Peluso had a tradition in her political ecology class. Every semester, she'd walk into the second or third class armed with an Indonesian machete (*parang*) and a globular, pungent, spiky fruit.

In front of her transfixed students, she'd slash through the well-protected rind and dig out the creamy white or yellow flesh inside. The odor of the durian fruit, which can weigh up to eight pounds, is so intensely sulfurous that several Asian countries have banned it on public transportation and in hotels. (Those that make it to the United States have had much of the smell bred out of them.) When she handed out pieces of the surprisingly floral-tasting fruit, a flavor beloved across Southeast Asia and China, "everyone was always excited," she says. But Peluso, who retired in 2024 after almost three decades as a faculty member in the Department of Environmental Science, Policy, and Management (ESPM), wasn't just serving up an exotic snack.

Mathew Burciaga (Peluso); AdobeStock (durian); Courtesy of Nancy Peluso (forest photos)

Peluso with an East Kalimantan local during her 1979-80 fieldwork with the Man and Biosphere Programme's research project, "Interactions Between People and Tropical Forests."

Peluso visiting an ancestral durian tree in West Kalimantan with descendents and their neighbors.

Peluso is a renowned figure in political ecology, a subdiscipline of geography and part of environmental studies programs around the world. The field is concerned with the ways power relations shape environments and how social and environmental processes, in turn, influence power relations. Studying the ways that human and nonhuman worlds are entangled, political ecologists trace connections between everything from global market forces and Indigenous communities to logging companies and local governments—and even between forest dwellers and trees. They examine the interactions between national governments, environmental activists, local people, and transnational supply chains. Untangling these intricate webs, they may then try to find strategies for protecting the environment and the rights of those who live on the land.

"The politics of land control and resource access are intense and hugely profitable for various interests," says Peluso, whose works focused on Indonesian forests are considered foundational texts in the field. "So, if you don't understand the cultural politics and social histories of these spaces and their conflicts," she continues, "you're not going to be able to change things."

To a political ecologist like Peluso, the durian is far more than a fruit. It's a window into the way social, political, and natural worlds collide. The forests of Kalimantan where the fruit grows may look like patches of preserved, untouched wilderness, but these verdant landscapes have been engineered by people over centuries. They have more in common with Jakarta or Bandung—two of Indonesia's complex, vibrant cities—than one might think. "I don't believe there are untouched forests," says Peluso. "Everything is in some way socio-natural."

In Kalimantan, the durian trees—which can grow up to three arm-spans wide—form an organic historical archive. They harbor family histories and tales of local dealings and conflicts. These trees live for seven to ten human generations, maybe more" says Peluso. "They're full of spirits and stories."

But how do you get the trees to give up their stories? How do you decode a forest?

GLOBAL CONNECTIONS

Peluso's long connection with Southeast Asia began by chance. She grew up in Connecticut in a nonacademic family, but always had an urge to explore the world. "I didn't know that there were jobs where you could get paid to travel and live in different places," she says. "I just had no idea."

She attended a Quaker-run college in New York state, called Friends World College (FWC). Now a part of Long Island University called LIU Global, the program sent students to its centers across the world to learn by doing. Besides seminars during the first month in each place, there were no classes. Peluso's first stop was San Francisco, where she focused on visual anthropology.

After a year of work, Peluso grew restless. In 1973, while interning with a photographer in Paris as part of her FWC program, she decided to make her way to Asia. "A woman I knew had a boyfriend who was in Borneo; he had sent pictures of longhouses and forest-dwelling people," she said. "I thought, 'that's what I'd really like to do.'" After another year of work in San Francisco, her advisor directed her to Java, "as more cosmopolitan," he said. Two years later, Peluso wrote an undergraduate thesis about the daily lives of landless women market traders. After graduation, she stayed to teach English and figure out her next steps.

Four and a half years after arriving in Java, Peluso was offered an opportunity to join a research team funded by the Man and the Biosphere Programme, which UNESCO had launched in 1971. The team would study relationships between people and tropical forests. Peluso relocated to East Kalimantan, the still lush forests of Borneo. "My task was to travel around and meet with small-scale traders and collectors of rattan, resins, birds' nests, and other nontimber forest products," she says. She became fascinated with the ways people not only made their livings from the forest but were also involved in creating those forests.

Wishing to expand her knowledge of the ways resources were distributed in the forests, Peluso applied to graduate school in 1980. She earned her master's degree and PhD at Cornell University in what students began to call *natural resource sociology*. The term *political ecology* was still rarely used at the time. Peluso helped pave the way for what the field would become with a pioneering doctoral dissertation about long-term conflicts in Javanese teak and nonteak forests.

In Java, colonial and post-colonial government forest managers had severely curtailed the access of millions of rural people living beside the forests and in forest-locked enclaves.

The teak forests had been claimed by the Dutch colonial rulers in the early 19th century and monopolized by the state toward the century's end. Forest villagers were forced to work them. After Indonesian independence, the boundaries of *political forest* lands and all forest species were declared state property, with the new state accepting colonial boundaries as national law.

Peluso's research showed that restricting local people's access to the forest resources claimed by the state took away their livelihoods. Violent encounters between foresters and villagers were rampant. This lack of forest access, except on the terms of the Indonesian Forestry Department, was leading to poverty and conflict.

In 1992, Peluso's book *Rich Forests, Poor People* was published—a groundbreaking study that analyzed the rela-

tionships between Javanese peasants and state forest politics over 300 years. Peluso suggested changes to locally relevant and national forest management policies, with the aim of giving peasants a greater voice in these decisions.

The text made waves, and it was widely read in Indonesia. "It was the first book about these forests and their history, and how policies during colonial rule formed the basis of the post-colonial reality," says **Suraya Afiff**, PhD '04 ESPM. Now a professor of anthropology at the University of Indonesia and the President of the Indonesian Anthropological Association, Afiff read the book while working for one of the first Indonesian environmental NGOs, and it propelled her to study with Peluso at UC Berkeley.

FIELDWORK FAMILY

According to Afiff, Peluso's long-term commitment to the people and places she studies is uncommon among Western academics. "For many scholars, you get the funding and you travel, and that's that," she says. Peluso's practice is antithetical to "parachute science," in which researchers from rich countries arrive in parts of the Global South to extract data, often sidelining the work of local researchers. "Nancy considers these villages part of her family," says Afiff. "She gets invited to weddings. She works with local colleagues. She keeps in touch with forest communities via WhatsApp."

These close relationships have allowed Peluso, across 11 books and almost 100 articles, to develop rich and detailed accounts of Indonesia forest-dwellers' worlds. Through long conversations with the people she works with, and many years of close collaboration, she is still intrigued by the ways that conflicts over resources shape so many people's lives. "I always live with the villagers with whom I am engaging," she says. "I try to learn how to see things from their perspectives, however limited my view will be. There are so many intangible rewards, from working with them, learning their stories, and understanding how they fit themselves (or don't) into a world in which their environments and their lives are changing all the time."

It's an approach that has rubbed off on her students. Ten years ago, Peluso accompanied then graduate student **Juliet Lu**, PhD '20 ESPM, on a fieldwork trip to Yunnan, China. Lu was exploring the way the Chinese government was using rubber plantations as a means of extending state power. "You could just tell she was an expert at building new relationships," says Lu, who is now an assistant professor at the University of British Columbia (UBC). "We spent a lot of time with one of the

"I don't believe there are untouched forests. Everything is in some way socio-natural."

Peluso with research assistants, friends, and adopted family in East Singkawang in 2014.

Peluso holding a durian during a UC Berkeley class in the 2000s.

Peluso and research assistants for her current project, "Women's Mobile Labor, Forest Plantations, and Agrarian Change," in East Java, Indonesia. From left: Melly Setiawati, Agus Purwanto, Peluso, and Debbie Prabawati.

Courtesy of Nancy Peluso

main connections I had, having meals together, visiting their homes and meeting their family members, taking time to just be slow and see how people lived."

The care and creativity with which Peluso fosters relationships extends to her students, too. In 2012, Peluso was awarded UC Berkeley's Distinguished Graduate Student Mentoring Award, and many of her students have gone on to become celebrated political ecologists. For **Catherine Corson**, PhD '08 ESPM, Peluso's political ecology class was life-changing. "I learned how to ask really important questions about power and access to natural resources," says Corson, who is now a professor of environmental studies at Mount Holyoke College. "And now, I use a lot of things I learned in that class with my own students."

At ESPM, Peluso directed the Land Lab, a collective of political ecology researchers working on issues relating to environmental conflict and land and resource access. For Lu, Peluso's group was so important that she decided to create a similar collective at UBC. "It's a way of approaching academia as a communal practice," says Lu. "It's been really transformative for a lot of our students."

Peluso's work emerged from a rich network in ESPM, particularly in the departmental division of Society & Environment. She has collaborated with other trailblazing ESPM faculty, many of whom were the first generation of women researchers in their fields, including professors **Louise Fortmann**, **Sally Fairfax**, **Lynn Huntsinger**, **Barbara Allen-Diaz**, and **Carolyn Merchant**, among others. "That group was so amazingly inspiring," says Peluso. "It used to be hard for women, especially social scientists, to be heard in the department, but it was easier for me, and soon after, my colleague **Kate O'Neill**, thanks to the pathways they opened." In 2009, Peluso succeeded Fairfax as the Henry J. Vaux Distinguished Professor in Forest Policy. And in 2021, 35 of Peluso's former students and colleagues successfully nominated her for one of the highest accolades in her field: the Distinguished Career Award from the American Association of Geographers' Cultural and Political Ecology Specialty Group.

Peluso's peers lauded her "deep, grounded, longitudinal" empirical research in Indonesia. But the decision to maintain such close links with her field sites over a long period of time was also practical. Balancing fieldwork with raising a young family in the US, Peluso couldn't spend more than a month or so at a time in Indonesian forests and villages. So she kept going back to the same place, after shifting her focus to a base in West Kalimantan (Indonesian Borneo). "I always returned to the same village, lived with the same families, and largely engaged with friends over years of visits without research assistants," she says. It was during these repeated trips, year after year, that she learned about the social lives of durian trees, rubber trees, and eventually, gold mines.

THEORY AND REAL LIFE

The durian trees of West Kalimantan, Peluso has argued, are key to the forest's history, as well as to the social histories of the people who planted, cared for, and lived among them. The social relations around the trees and the ways families managed access to the fruits opened a library of information about the socio-natural worlds of the people she worked with in this new research site. Durian trees told stories of the ancestral forests that they anchored. They told about kinship and landscape histories. "The trees all have names," says Peluso. Sometimes, the name is taken from the person who planted the tree. But individuals or communities also renamed trees to mark events that took place nearby, such as disputes between family members contesting each other's rights to the fruit. "Every tree contains a family history."

When a heavy fruit crashes to the floor of a forest garden, there are intricate systems in place for deciding who gets to immediately eat or keep the treasure. "If my friend Apong planted the tree, it's his tree, and he gets to decide who has rights to harvest the fruit—by waiting in shelters built nearby," she says. But the question of how to divide the resource becomes more complex in subsequent generations. Apong's children might rotate waiting in the mountain shelter. Or he may assign specific trees to specific children or other family members and friends for a certain period. In the third human generation, the tree becomes a "grandparent tree," and all the grandchildren of the planter have rights to the fruit. "All these cousins have to figure out how to rotate access." For much older trees, though, understanding who has rights can be difficult— but still, there are usually systems in place for dividing the harvest.

Before Peluso's close observations on access to these iconic fruit trees, and those of her colleagues from the New York Botanical Garden studying tropical fruit tree domestication in roughly the same region, these details about the durian forests as ancestral, created forests were not widely understood beyond the forest settlements.

Peluso's work is also renowned for its development of theory and concepts based on the contexts, experiences, and practices of everyday life. After passing the Indonesian Basic Forestry Act of 1967, government and timber industry advisors mapped large areas of forest across Kalimantan. Unsurprisingly, these maps failed to represent the rights that Indigenous people had as longtime residents on the land. In response, forest dwellers and activists made maps of their own, which incorporated their long histories of forest use and their customary management of access.

In 1995, Peluso called the concept counter-mapping, and scholars have since documented examples of the practice all over the world, from the Arctic to Namibia. Indigenous peoples turn mapmaking into a form of resistance—a way of subverting the official cartography that seeks to erase them and their claims, quite literally, from the map.

Since then, Peluso has continued innovating theoretical concepts that have become important political ecological ideas. Collaborating with the political ecologist Peter Vandergeest, Peluso introduced the concept of the political forest. Forests have always been produced, converted, and protected through politics, often contentiously and sometimes violently. Regulating peoples' access to resources, providing recognition and legitimacy to some while excluding and criminalizing others, are political acts.

The political forest idea also led Peluso and Vandergeest to think deeply about the concept of territory and state territorialization—the ways states used coercion to lay claim to land. Their respective, long-term research in Indonesia and Thailand created opportunities to make comparisons of forest politics and territorializing practices. There is a disconnect, they argue, between people's experiences of space and the abstract, empty grids that governments impose on areas they hope to control, erasing at the same time pre-existing territorialities and claims. Understanding this tension between lived and abstract space can help shed light on the causes of conflicts between forest dwellers and government actors.

What unites each of these concepts is the idea that things that might seem solid and reliable—like maps, territories, landscapes, and forests—are created through social processes and practices. These processes can take place at a distance, involving flows of money and resources that crisscross the globe. In an ongoing research project, Peluso has been studying the ways that rural Javanese women, who work as caregivers and housekeepers in cities such as Hong Kong, are reshaping their home forests in Java as they send money home to their families. These cash remittances from foreign currencies are then invested in rural resources, directly and indirectly changing the composition of and claims on mountain forests. "Migration," says Peluso, "is a political forest maker, too."

Conceptually sophisticated, Peluso's ideas remain grounded in the detailed empirical study of environmental change and conflicts. "These theoretical concepts emerged from what I witnessed on the ground or thought about with collaborators. I thought, 'how do you describe this? Is there a word for it?'" says Peluso. "I always try to teach my students that theory comes out of real life."

"I always try to teach my students that theory comes out of real life."

Nancy Peluso's photography documenting the labor and lives of small-scale gold miners and workers in the West Kalimantan region of Indonesian Borneo has been featured in exhibits around the world. Most recently, the images were showcased at the Research Institute of Humanity and Nature in Kyoto, Japan, and an ongoing digital exhibit is available through the UC Berkeley Environmental Design Library.

Scan for more

Peluso and former Land Lab graduate student Juliet Lu (far left) while Lu was conducting fieldwork in Yunnan, China.

Nancy Peluso (mine); Courtesy of Juliet Lu (group)

A World of Climate Data

A collaborative network of scientists is measuring the breathing of the biosphere around the globe.

BY JANET BYRON
ILLUSTRATIONS BY VALERIE CHIANG

When humans breathe, we take in oxygen from the air, transfer it into our blood, and breathe out carbon dioxide. With plants, it's the reverse: they "breathe" by taking in carbon dioxide, depositing it into their tissues via photosynthesis, and then releasing oxygen. This process offers potential for the Earth's ecosystems to take carbon out of the air, which is crucial as humans race to reduce the greenhouse gas emissions that are fueling the rapid advancement of climate change.

Plants also release carbon dioxide when they decay, and when they burn in wildfires. Studies by the Intergovernmental Panel on Climate Change and others estimate that the uptake of CO2 exceeds these releases, and that plants may take up and store as much as a quarter of human-made carbon emissions. To better understand the capacity of ecosystems to act as long-term carbon sinks, scientists at Rausser College of Natural Resources and across the globe use micrometeorological towers fitted with sensors capable of measuring the ebb and flow of carbon dioxide and other greenhouse gases.

"When you breathe, a mass flow—air velocity multiplied by the concentration of gas—moves into and out of your mouth," says **Dennis Baldocchi**, a professor of biometeorology in the Department of Environmental Science, Policy, and Management (ESPM). "We're measuring that in ecosystems with a set of sensors placed over crops, grasslands, forests. We can see the eddies—the movement of air up and down—past our sensors, and the amount of gases they contain."

Baldocchi helped pioneer this technology and methodology, called eddy flux, or eddy covariance. For two decades he led FLUXNET, a global network of scientists that shares open-source data, and his Biometeorology Lab has trained dozens of graduate students and postdoctoral researchers who now manage flux tower projects from the Bay Area and Arkansas to Panama and Estonia.

"Grasslands and forests and every single kind of terrestrial ecosystem around the globe are 'breathing.' It would be very cool if, just the way we see our chests rise and fall, there was a way to see it," says **Margaret Torn**, BS '84 Conservation

Pictured clockwise from top: FLUXNET researchers Kyle Delwiche, Margaret Torn, Robert Shortt and Irene Alorda-Montiel, Dennis Baldocchi and former undergraduate student Jose Sanchez.


NORTH
ATLANTIC
OCEAN
$F = \rho_a ws \approx \rho_a \cdot w's'$

and Resource Studies; PhD '94 Energy and Resources, a professor in the Energy and Resources Group and a senior scientist at Lawrence Berkeley National Laboratory.

Torn coordinates the AmeriFlux Network, a network of towers in North, Central, and South America. "Having an eddy covariance tower to watch cycles in the data is maybe the closest we come to actually see the breathing of the biosphere."

A global collaboration network

While researchers had measured fluxes of mass and energy since the 1950s, the eddy covariance technology developed in the 1980s introduced the capability to measure carbon dioxide flux, the rate at which CO2 moves into or out of a land surface. The approach allows scientists to take flux measurements above forest, crop, grassland, chaparral, wetland, and tundra ecosystems, attaching sensors to towers ranging from 15 to 225 feet high. In addition to carbon dioxide, water vapor, and other trace gases, the micrometeorology towers measure a range of environmental factors including sunlight, temperature, and soil moisture.

"In the early days of this technology, only four or five groups were able to make direct measurements of carbon dioxide fluxes," says Baldocchi, who was working at the National Oceanic and Atmospheric Administration (NOAA) at the time. "The importance of understanding how ecosystems are consuming carbon dioxide through photosynthesis or producing it through leaf and soil respiration at ecosystem scales kick-started our desire to make continuous, year-round measurements."

As a scientific community coalesced around measuring carbon fluxes, an international and multidisciplinary group of scientists, including Baldocchi, met in 1995 in La Thuile, Italy, for a workshop where some of the first continuous, years-long flux measurements were presented.

Pictured from left: Trevor Keenan and Tianxin "Carlos" Wang, PhD '24 Environmental Science, Policy, and Management.

One outcome of the workshop was the first meeting in 1997 of FLUXNET, a loose "community of the willing," with Baldocchi at the helm. FLUXNET compiled, archived, and distributed eddy covariance data globally and calibrated it to ensure consistency and comparability, while building the scientific community via workshops, conferences, and technical support.

"The fun part was developing friendships and collaborations with people from all over the world," Baldocchi says.

Ecosystem responses to climate changes

Another important outcome of the La Thuile workshop was the launch of the AmeriFlux Network in 1996, with support from the US Department of Energy, NASA, NOAA, and the US Forest Service.

Based at Lawrence Berkeley National Laboratory, the AmeriFlux Network now has more than 500 towers in the Americas making eddy covariance measurements at any given time. By 2025, the network had amassed 3,562 site years of data from 11 countries, which has been downloaded 42,141 times. "The importance of these networks is for people to be able to understand the global carbon cycle and how ecosystems are functioning around the world," Torn says.

Torn leads the AmeriFlux Management Project, which launched in 2012 with ongoing support from the US Department of Energy. The project serves the robust AmeriFlux Network with technical support, data quality control and processing, assistance in ensuring continuity in the longest-running sites, and community events and training. In addition to validating the ability of ecosystems to act as carbon sinks, Torn says, research by the AmeriFlux Network has greatly contributed to scientific understanding of how ecosystems recover from disturbances such as logging, wildfires, and extreme weather events.

"Ecosystems tend to change a lot, but they recover in one way or another," Torn says. "A fire may cause a lot of erosion and degradation, but new plants come in or seeds resprout into trees. Recovery from disturbance is an important part of our overall carbon cycle and climate system."

Understanding how ecosystems cycle carbon

When Baldocchi arrived at ESPM in 1999, he organized the second international FLUXNET workshop in Marin County. That same year, sensors mounted on NASA's Terra satellite began sending back Earth-scale data on carbon cycling, energy absorption, evaporation, and other climate-related factors. In addition to validating satellite data, eddy covari-

ance researchers sought to understand carbon cycling at the ecosystem level.

"It's very hard to tell from remote sensing what an ecosystem is actually doing, or how much carbon is being taken up," says **Trevor Keenan**, an associate professor in ESPM and director of the FLUXNET Coordination Project. "Eddy covariance towers are literally taking the only observations available at the ecosystem scale."

In 2001, Baldocchi and colleagues reported key findings from FLUXNET data, including that the age of a forest influences its ability to exchange carbon dioxide and water vapor, and that the efficiency of ecosystem carbon dioxide exchange (the amount of carbon assimilated per unit of sunlight) under cloudy skies was about twice the efficiency under clear skies. "The quality of light has a big influence on photosynthesis of a whole forest," Baldocchi says.

Over the years the scientific community using eddy covariance grew to about a dozen regional networks—including the ICOS (Integrated Carbon Observation System) in Europe and AsiaFlux networks—that are involved in the gathering and processing of open-source flux data.

Baldocchi led FLUXNET for more than two decades and operated 15 towers in the San Francisco Bay-Delta Watershed and Sierra foothills, and his former students and postdoctoral researchers now operate more than 50 flux towers in California, nationally, and globally. For example, **Alex Knohl** of Germany's University of Göttingen manages towers in palm oil fields and mountain tropical rainforests of Indonesia; **Matteo Detto** of Princeton University monitors towers in Panama's tropical, broadleaf, and evergreen rainforest; and **Kuno Kasak**, currently a visiting researcher in Baldocchi's Biometeorology Lab, operates towers in an abandoned peat-extraction site and restored wetlands in Estonia.

FLUXNET coordination project

Today, an estimated 3,000 flux tower sites operate worldwide, largely due to dramatic improvements in sensor technology and affordability as well as greatly expanded computing power and storage. About 500 sites currently share measurements with FLUXNET, Keenan says, and a few hundred more are joining this year.

The resulting long-term, continuous datasets are helping climate scientists understand the ability of various ecosystems to sequester carbon, the effectiveness of climate solutions such as wetland restoration and forest regeneration, and the climate impacts of extreme weather events. The number of scientific papers based on eddy covariance data published has grown from a handful during Baldocchi's early days in the field to hundreds annually.

"We need to make these long-term measurements on ecological timescales, and in doing so we have to plan for generational succession so data collection can continue," Baldocchi says. He's passing the torch to Keenan, who now leads the FLUXNET Coordination Project, which received $2 million from the National Science Foundation in 2021 to facilitate international collaboration, offer training and research opportunities, and coordinate how global open-source flux data is shared.

In the past, FLUXNET periodically released comprehensive datasets compiled from contributing flux networks. "There was a massive effort to process and release the data, and that was it," Keenan says. "We're moving toward a model where the data will be dynamically updated and continuously accessible." The first release of the new data system, being developed by ICOS, AmeriFlux, and other regional networks, is expected by the end of this year.

Importantly, future versions of the FLUXNET data infrastructure will include measurements of methane, a more potent but less prevalent greenhouse gas that degrades about 10 times faster than carbon dioxide. "Methane sensors have proliferated over the past few years, and now many sites are making those measurements," Keenan says.

Kyle Delwiche is deputy director of the FLUXNET Coordination Project and co-facilitator of the FLUXNET Community Council, which meets monthly in two time zones so that scientists from all over the world can participate. Delwiche's research focuses on methane emissions from natural ecosystems, particularly over restored wetlands.

"If we make changes today that reduce our methane emissions, we'll see the effects of that far sooner than for CO2," Delwiche says. "The more we understand the methane budget for the world, the more we can predict what's going to happen with the climate."

Studying nature on its own terms

As Baldocchi heads toward retirement this summer, his contributions to the science of eddy covariance have been recognized with top honors in the field. "Dennis has pushed the boundaries of the application of micrometeorology theory and technique," Keenan says. "He's been a cornerstone of the community, a huge ambassador for the science and the FLUXNET network, and the glue that has kept the regional actors together and moving forward."

Baldocchi credits his too-many-to-name scientific mentors, colleagues, students, and research teams for keeping the eddy covariance data flowing. "We now have over two decades of data from hundreds of sites around the world," he says. "We have to study nature on its own terms—measuring how it's responding to all these multifaceted changes. The key to our success has been creating and sharing data so that the whole adds up to more than the sum of the parts."

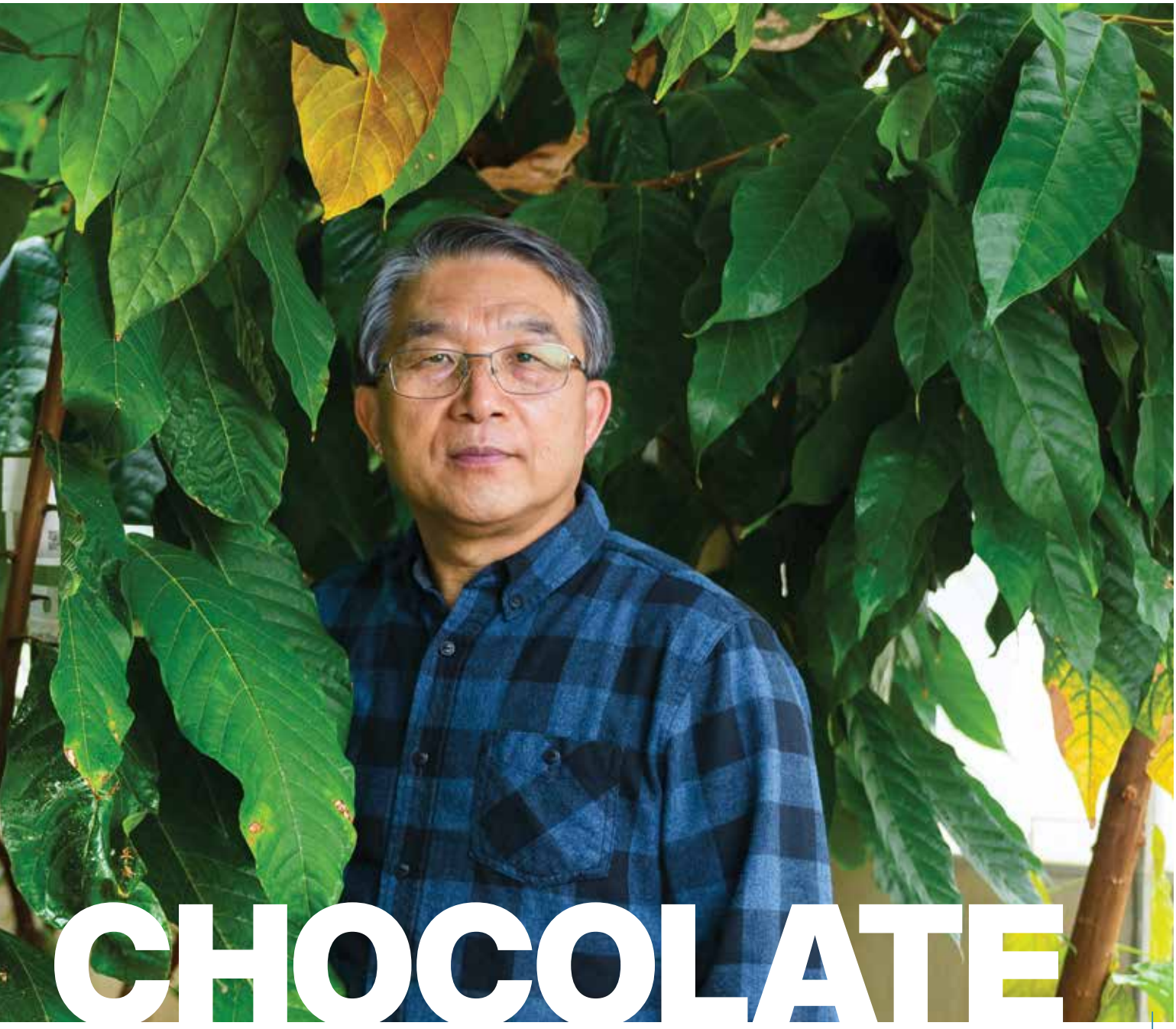
Not THE END OF

Berkeley researchers are working to safeguard the planet's supply of cacao from disease.

BY BRAD BALUKJIAN | PHOTOGRAPHY BY MATHEW BURCIAGA

A world without chocolate seems like a dreary place. But according to **Brian Staskawicz**, it's not hyperbole to fear the confection's extinction.

Chocolate, made from the cacao plant (cocoa is the powder, cacao the organism), is a combination of fermented and ground cacao beans, sugar, and milk powder that undergoes a labor-intensive process of drying, heating, and cooling before it melts in your mouth. Seventy percent of it comes from West Africa, mostly from Côte d'Ivoire and Ghana. But the crop is under siege—disease wipes out 20-30% every year, and now climate change is piling on. Excessive rains damaged last year's harvest as did the ravages of Cacao Swollen Shoot Virus (CSSV), an infection spread by tiny insects called mealybugs. Once the plant is infected,



CHOCOLATE

Brian Staskawicz (left) and Myeong-Je Cho stand among potted cacao trees growing in an Oxford Tract greenhouse.

cacao stems swell, leaf veins turn red, leaves turn yellow, and within three to four years the trees die. There is no cure. Reductions in supply last year made cacao a more lucrative commodity than bitcoin—good for investors but bad for your wallet—as prices soared.

When the Innovative Genomics Institute (IGI)—a collaboration between UC Berkeley, UC San Francisco, and UC Davis—launched in 2015, saving chocolate was not top of mind. But when Staskawicz, a longtime professor in the Department of Plant and Microbial Biology, was recruited to apply genetic engineering solutions as head of the IGI's Climate and Sustainable Agriculture program, he thought big and broad, well beyond the scope of staple crops.

"If you can use this technology to save a consumer crop like chocolate that everybody loves, you'll likely start to gain more acceptance of these methods," Staskawicz tells me, leaning back in an office chair in a brightly lit conference room at the IGI building. He's flanked by **Myeong-Je Cho**, director of the IGI's Plant Genomics and Transformation Facility (PGTF).

"This is also one of the major crops for developing countries," Cho says, reminding us that cacao provides the livelihood for about two million small-scale farmers in Côte d'Ivoire and Ghana, where they make only a few dollars a day.

The technology the pair speaks of is headlined by CRISPR, a form of genetic engineering pioneered by UC Berkeley professor and IGI founder **Jennifer Doudna**.

The mouthful of a name (Clustered Regularly Interspaced Short Palindromic Repeats) refers to actual sequences of DNA found in bacteria that reflect past viral infections, but as Staskawicz explains, it's more useful to think of it as "a natural immune system in bacteria" that we can adapt for our purposes. The gist: scientists hijack the DNA blueprint used to make antiviral molecules in bacteria and insert them into a host organism's DNA so that it can either defend itself from viruses or alter the host's DNA to produce other desirable traits.

CRISPR is a game changer. Staskawicz and Cho see it as their powerhouse weapon in the fight to improve global food security. While Earth's population will eventually decline given current models, it will peak around ten billion sometime after 2050—a lot of mouths to feed in a volatile climate that threatens food supply. IGI researchers apply CRISPR to wheat and rice to address this challenge, along with specialty crops like tomatoes and cacao.

"I don't think people understand that we have a serious problem," Staskawicz warns. "Once you don't have food, you don't have food security, and that will cause wars. People will start invading to get food."

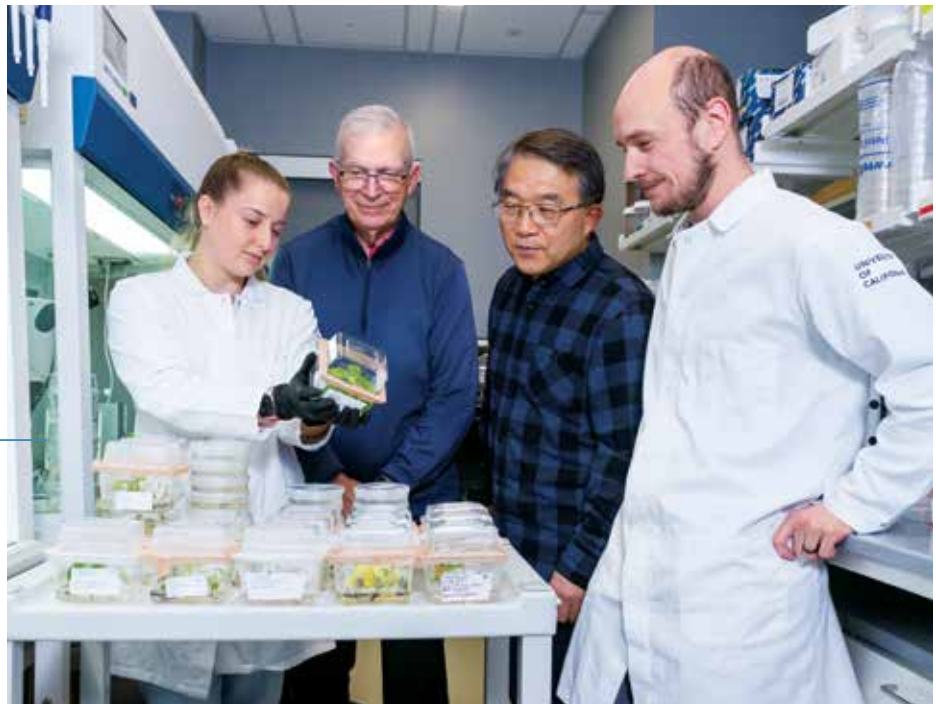
THE CACAO CHALLENGE

Over the course of an hour, Staskawicz and Cho give me a crash course in genetic engineering, patiently walking me through the basics and turning the knob to eleven only when necessary. Staskawicz's pedagogical instincts have been honed throughout a half century during which entire disciplines have been invented. He got his PhD studying disease in bean plants at Berkeley in 1980 and returned three years later as an assistant professor.

Cho also bleeds blue and gold, having worked under legendary Plant and Microbial Biology professors like **Bob Buchanan** and **Peggy Lemaux** for more than a decade during the 1990s and mid-2000s. He also spent several years in industry, co-founding Byotix, Inc. and later working for DuPont Pioneer (currently Corteva Agriscience). Shortly after Doudna tapped Staskawicz to run point on IGI's agricultural genomics program, Cho arrived to head up the PGTF's research efforts. And then, chocolate came knocking.

With CSSV decimating cacao trees in West Africa, it's getting more difficult for farmers to grow the amount of cacao that chocolate producers need. Mars Inc.—producer of Snickers, Twix, and many other popular sweets—approached IGI about potential opportunities.

But cacao presented some major problems. It's a finicky, slow-growing plant in vitro, and unlike wheat and rice, it's highly genetically diverse, meaning it can't be bred easily from seed in the lab. However, to produce plants that are genetically identical to the parent, it can be propagated through somatic embryogenesis, a process that involves reproducing plants from just a tiny piece of flower petal or staminode tissue. After this process, the researchers infected the tissue with Agrobacterium, using it as a sort of Trojan horse to smuggle DNA into the genome of their test plants. Whole plants were later regenerated from these infected tissues. Tissue from these whole plants glowed when placed



From left: Researcher Abigail Stevens, Brian Staskawicz, Myeong-Je Cho, and researcher Maxwell Vetterli examine a cacao plant in growth medium at the Plant Genomics and Transformation Facility.

Gene edited cacao plants start as a tiny propagation from a flower petal or staminode tissue, then mature in growth medium before they are planted in soil and eventually become full-size cacao trees over 15 feet tall.

under a fluorescence microscope, verifying that the gene had been successfully delivered.

"It was extremely difficult," Staskawicz says. "It took more than a year to actually regenerate a cacao plant." The IGI is now one of only a few institutions in the world capable of successfully transforming and editing the cacao genome and growing the plants in culture.

Once this genetic transformation was established, the researchers put Agrobacterium to work once again, this time packaging it with the CRISPR machinery that would arm cacao with defense against CSSV.

SAVING CHOCOLATE

After an hour of discussion, Staskawicz and Cho are eager for me to see the actual work—the plants and the science in action. A few minutes later we're on the move in the IGI halls. Cho ushers me into the main lab, a bright chamber packed with flow hoods, lab benches, microscopes, and researchers. Here and in multiple walk-in growth chambers are cacao plants in various stages of growth, from the early stages of a tiny green leaflet with squiggly brown roots sitting in a Petri dish to the bright green cluster of a potted plant.

The team's first major CRISPR experiment with cacao is nearing completion. Based on the known genome of CSSV, they designed a guide RNA sequence that is complementary to the virus' DNA, which they packed with the DNA code for a type of molecular scissors, a protein called Cas9, in a single cell of Agrobacterium, which acts as genetic engineering's FedEx. The team inoculated young cacao plant tissue with the Agrobacterium and its CRISPR package; the cacao cells took up the package, and the Agrobacterium inserted its deliveries into the cacao genome. When the plants are infected with CSSV, if all works as planned, the guide RNA will allow the cacao to detect and bind to the invader, and the Cas9 protein will chop it up, destroying the virus.

Plants in the Oxford Tract greenhouse—some now nearly 13 feet tall—are almost large enough to be transferred to a Mars facility where they'll be tested by collaborators there for virus resistance.

In addition to these experiments, the team has plans to use CRISPR to knock out a gene in the cacao genome, enabling broad disease resistance.

The toughest challenge may not be viruses like CSSV, but public perception itself. "We don't want to make the same mistakes as GMOs," Staskawicz says. "There was a lot of public backlash and fear of Frankenfood." Debate continues over whether or not CRISPR-edited crops should be labeled as GMO; generally speaking, GMO is reserved for the introduction of DNA from an unrelated species into a host's genome, and technically the CRISPR machinery, derived from bacteria, fits this definition. But there's the potential to remove the CRISPR molecules after the gene editing phase post-edit—a set of experiments Staskawicz is eager to start.

The team at the IGI knows that winning the war on climate change and food insecurity means gaining the confidence of the general public, and they have dedicated an entire arm of the operation to public impact. The IGI's Public Impact team is focused on fostering meaningful dialogue with diverse stakeholder communities, providing free educational resources, promoting responsible governance, and ensuring equitable access.

Overcoming CSSV in a way that is palatable to consumers will go a long way toward securing chocolate's future, but other challenges remain—like another insidious disease threat called black pod rot and local government policies in West Africa fixing prices for farmers. The tools and willpower appear to be there from groups like the IGI. If they succeed, Halloween will remain flush with chocolate for generations to come.

WOLF PRIZE WINNER

In March, Brian Staskawicz was awarded the prestigious Wolf Prize in Agriculture in recognition of his groundbreaking discoveries of the immune system and disease resistance in plants. Staskawicz shares the honor with Sainsbury Laboratory researcher Jonathan Jones and University of North Carolina, Chapel Hill, biologist Jeffery Dangl, whose research also shaped the field of plant immunity and opened up new strategies to enhance resistance and control a broad spectrum of plant diseases.

Q&A

The California-China Climate Institute

INTERVIEW BY JULIE GIPPLE

The California-China Climate Institute (CCCI) is a UC-wide initiative housed jointly at Rausser College of Natural Resources and UC Berkeley's School of Law. Launched in September 2019 and led by former California Governor Jerry Brown, BA '61 Classics, the Institute spurs climate action through research, training, and dialogue in California and China. As CCCI celebrates five years, *Breakthroughs* sat down with the Institute's director and a student affiliate to learn about specific initiatives and the outlook for the years ahead.

These interviews have been edited for length and clarity.

Courtesy of Fan Dai

Fan Dai

Director, California-China Climate Institute

Fan Dai's research expertise includes market mechanisms for climate change mitigation, climate diplomacy, and governance. At CCCI, she leads research on subnational climate policy and long-term planning for carbon neutrality. Dai has previously served as California's liaison on economic and environmental initiatives with China and as senior advisor at both the California Environmental Protection Agency and the California Governor's Office of Business and Economic Development. She was awarded the Clean Energy Champion Award by the State of California in 2024.

From left: Fan Dai, former California Governor Jerry Brown, and Chinese Special Climate Envoy Xie Zhenhua in November 2023.

Courtesy of Fan Dai

CCCI highlights so far?

CCCI's strength is coordinating high-level communication between the US and China about climate change efforts. For example, in 2020 we convened an initial dialogue between Chinese Special Climate Envoy Xie Zhenhua and John Kerry even before his appointment as US Special Presidential Envoy for Climate was announced. More recently, we held a meeting of more than 340 national, state, provincial, and city leaders from across the US and China to discuss subnational climate action related to the Sunnylands Statement on Enhancing Cooperation to Address the Climate Crisis. We also played an instrumental role in Governor Gavin Newsom's 2023 visit to China and are serving as secretariat for several of the climate-related memorandums of understanding signed or renewed during that trip. The Institute's policy research has informed many dialogues, served as a resource for policymakers from both countries, and advanced climate diplomacy efforts globally.

What climate-related interests do the US and China share?

As the two biggest greenhouse gas emitters in the world, the US and China arguably share a responsibility to be the most important players in climate solutions. If they coordinate to deploy and scale renewables, the costs of transitioning to clean energy could be reduced. If they don't cooperate, the entire process will be slower, and ultimately, costs will be higher for consumers everywhere. The two countries have very different agendas, and their interests sometimes conflict, but I would argue that climate change deserves to be considered separately from other issues.

What can the countries learn from one another?

In an article in *Nature* last December, CCCI offered numerous examples. California's cap-and-trade program served as a blueprint for China's local Emission Trading Scheme pilot programs many years ago. The state's experiences with energy efficiency in buildings and with improving existing grid systems to integrate more renewables have also provided best practices for other countries. Now, the US could learn from China's experience developing, manufacturing, and scaling offshore wind technologies. China is also very advanced in deploying electric vehicles, with nearly 50% of new car sales being EVs in many provinces.

How might changing leadership affect climate action?

The first Trump administration taught us how to be resilient as an organization and to remain a force prioritizing climate action. We're already seeing some measures that deprioritize climate change in this second term. Still, over the past decade we've seen various groups—including ones in the private sector and civil society—that continue despite federal action. One such effort is the US Climate Alliance, a bipartisan coalition of governors taking state-led climate action. Climate change is increasingly regarded as a global threat, and many of the international collaborations already happening will not stop. CCCI will continue facilitating discussions and actions to help accelerate solutions for a net zero future.

How has CCCI advanced subnational climate action?

US states and Chinese provinces are developing ambitious climate targets and implementing these policies to achieve, ultimately, carbon neutrality. They provide lessons for shifting from ideas to action and collaborating at regional scales. Our research, in collaboration with partners including government agencies, evaluates state climate targets and policies, measures progress toward climate goals, and builds tools to inform decision-making.

China uses five-year plans to orchestrate larger changes in its economy, and the country's provincial 2021-2025 five-year plans provide a window into China's pivot toward a lower carbon economy. Last fall, we published a policy brief examining plans released by four of China's provincial-level municipalities, which detail actions being taken on carbon peaking and neutrality goals, environmental targets, and in sectors such as energy, transportation, industry, buildings, and natural and working lands. Our insights from the previous five-year planning period can help guide efforts as preparation for China's 15th five-year planning cycle for 2026-2030 begins.

Fan Dai (Cont.)

CCCI has also created state climate action maps that visualize subnational state and city actions codified in law across the US. We plan to expand the project to include maps of actions in Chinese provinces. We're also launching a project to create case studies from various subnational regions to complement the maps.

How are students involved with CCCI?
Part of CCCI's mission is to provide funding opportunities for students interested in China and climate change. Several student assistants worked on the mapping project, and through our student travel and independent fieldwork grant program, many students have advanced their independent research relating to China and/or US climate, environmental, and energy policy.

CCCI's priorities for the future?
We'll further institutionalize our work fostering research, dialogue, and training on subnational climate action. We'll also expand our external partners, broadening our impact and scope to include perspectives from other jurisdictions, academia, and the private sector. For example, we're starting a program called Pacific Climate Dialogue, which will consist of jurisdictions bordering the Pacific Ocean around the world. Many of the conversations we facilitated in the past were off the record, but we'd also like to explore making more dialogues available to the public.

I also hope that CCCI can increase research on climate adaptation and resilience at local levels, particularly as climate disasters become more frequent and urgent. We want to look at those holistically, assessing how we can harmonize human and planetary health while planning climate adaptation and resilience.

Mathew Burciaga

Xi Xi

Graduate student, Energy and Resources Group

Xi Xi uses interdisciplinary methods such as quantitative modeling techniques and policy analyses to assess impacts on emissions and energy use. Specifically, Xi Xi's work focuses on how developing countries may be affected by or benefit from tensions between China and the West and on China's emerging role in international development and global climate politics. This work has been supported through CCCI's Student Travel and Independent Fieldwork Grant Program.

Your path to Berkeley?
After earning my undergraduate degree in math, I spent a year as an investment analyst at the Massachusetts Clean Energy Center and then worked as an EPA consultant. I returned to China to do policy work after President Xi Jinping announced the country's goals of peaking carbon dioxide emissions before 2030 and achieving carbon neutrality by 2060. I learned a lot about policymaking and governance through working with both governments.

The Energy and Resources Group (ERG) graduate program was attractive to me because of its interdisciplinary approach. While modeling renewable energy systems I'm also using qualitative approaches to explore which models are the most appropriate and how to interpret their results.

Why specialize in US-China collaboration in Africa?
My interest in US-China collaboration in third-party countries stems from my personal experience. I'm a Chinese citizen, but I've lived a third

of my life in the US and feel deeply connected to both countries. In my research on energy grid expansion and industrialization in Africa, I hope to prioritize African interests while leveraging my understanding of American and Chinese interests in development in Africa.

It's challenging to develop Africa's utility grid without a strong industry sector, but lack of reliable power supply also hinders industrialization. It's a chicken-and-egg dilemma, and I'm focusing on how to create strategies to develop both sectors in tandem. At the same time, equitable development is important. While I was growing up in China, the predominant development theory was to help some people get rich first, and others would follow—a trickle-down idea. Now, more people are analyzing how to balance equity with development. I'm looking at how policies can be effective and also ensure equity. I believe experiences from and collaborations with both the US and China can be valuable.

Explain your work on green hydrogen?

Green hydrogen (GH2) is an emerging renewable energy technology that's very attractive for heavy industry and transportation. It's difficult to use electricity to power these sectors. However, GH2 can replace oil, gas, or coal as a fuel for combustion. The hydrogen is made through electrolysis, which must use electricity from renewable sources like wind or solar power to be considered "green."

Hydrogen derivatives are also important in the value chain. Hydrogen molecules' small size poses challenges in transmission and storage. Instead, GH2 can be turned into ammonia or green methanol, which is easier and safer to transport and store. Many people are also interested in using GH2 to make ammonia for fertilizer, which could significantly reduce emissions.

Most European countries have goals to increase GH2 use but lack enough solar and wind resources to produce large quantities of it, so they are sponsoring many GH2 initiatives in Africa. I'm evaluating Kenya's national GH2 strategy, pointing out potential technical, financial, and market risks of implementing the industry, offering mitigation strategies for those risks, and assessing potential equity impacts.

What environmental and equity impacts might arise?

Using electricity to create GH2 in countries where local people lack reliable power is a clear equity issue. Similarly, electrolysis requires clean water, which is already scarce in Kenya. Other distributive justice questions remain. Using Africa's solar and wind resources to create GH2 or derivatives for export to Europe easily continues the long colonial history between the two continents.

In Kenya, downstream supply chains are planned to produce green hydrogen derivatives, which could create value for Kenyans. But we need to assess who benefits: Is it those experiencing the environmental impacts of development or big corporations and foreign-funded projects? How can we ensure just distribution of costs and benefits? Last summer, with funding from the California-China Climate Institute, I visited Kenya and China to research this topic. I'll return this summer to share my modeling results with policymakers and prepare for further research.

Your take on changes to US-China relations in coming years?

Many predict that US-China relations will become more strained during the second Trump administration. This is important for Africa because there was already a lot of geopolitical tension there. Africa is a continent of massive growth potential because of its critical minerals and rich human and natural resources. It could also be a productive place for the US and China to collaborate and accelerate a rapid and just energy transition globally. The two countries' complementary expertise, experience, and resources can assist Africa in rapid sustainable development through technological and systematic leapfrogging.

As we face the global climate crisis, the US and China will remain players in Africa, and they can be very supportive in development processes. But a lot depends on how each country approaches the situation. There's a Swahili proverb about two elephants fighting, and it's the grass that gets hurt. And there's a Chinese proverb that tells the story of a bird trying to eat a shellfish, so it puts its beak into a shell, but the shell closes, and now they're stuck, fighting with one another. A fisherman comes in and gets them both. These are two very different metaphors that I think are relevant. When there's a conflict and a crisis, the third party can benefit from it or be negatively impacted. The question is, will African countries be the grass or the fisherman?

Xi Xi hosting a workshop on the roles of civil society organizations in Africa-China energy collaboration during the Forum on China-Africa Cooperation.

Everything In Life, From Water

ALI ODEH, 2024 BEAHRS ENVIRONMENTAL LEADERSHIP PROGRAM

BY CAROLINE CHAMPLIN

Water in Palestine is rarely just that. Often, it's salty. Sometimes it's polluted with waste. When people need it most, it may not be there at all.

"We are living in a hot area. This summer the situation became critical," says Ali Odeh, executive director of the Union of Palestinian Water Service Providers. "We have supply systems, but we don't have water. The pipes are empty."

In his role, Odeh oversees nearly 300 water service providers operating across Palestine, from Gaza to the West Bank, where he lives. Since the latest war began in Palestine, water has become potently infused with politics.

Some Palestinian service providers draw on groundwater and desalination plants, but to get by, nearly every provider has to buy additional supply from an Israeli company. It's a fraught dependency, and according to Odeh, a frequent topic of discussion in service provider meetings.

"There's lots of strong opinions," says Odeh, who serves as the mediator for the group. "You have to understand the politics, the technical, the financial, all in one."

Odeh has been at the center of this complex operation since 2017. He's earned international funding for local infrastructure improvements and conducted capacity-building programs for service providers, all amid ongoing geopolitical turmoil.

CRITICAL RESOURCE IN CRISIS

Last year, Odeh was selected to participate in Rausser College's Beahrs Environmental Leadership Program (ELP). For more than 20 years, the summer certificate program has drawn environmental and climate professionals from all over the world to the UC Berkeley campus, immersing them in a community of academics

Courtesy of Ali Odeh

leading in their fields. Over the three-week program, participants exercise problem-solving skills with case studies, role-playing, and presentations—all through a lens of ecological stewardship. A scholarship from the ELP through the Malcolm H. Kerr Endowment Fund, which offers support for ELP participants coming from the Middle East and North Africa, made it possible for Odeh to attend.

With water systems shattered by bombings and supplies held up at checkpoints, the lessons Odeh learned have been urgently needed back home. Many Palestinians are living on a fraction of the daily water intake recommended by the World Health Organization. Meanwhile, climate change is increasing temperatures and further exacerbating the humanitarian crisis in the region. "You can feel it here," Odeh says of the significant increase in temperatures. "It becomes very hard to live without air conditioning."

The faculty Odeh heard from at Berkeley are helping him approach the urgent resource crisis in Palestine from a common global perspective, governed by the same environmental forces and basic human needs.

"In our Quran, there is a verse: 'We make everything in life from water.' This program made me better understand the meaning of that," Odeh says.

Odeh was especially appreciative of UC Berkeley alum and longtime ELP advocate **John Gage**, BS '75 Conservation of Natural Resources, who gave him a copy of Professor David Sedlak's book, *Water for All*, which tackles the issue of worldwide water rights and emerging solutions for increasing access.

"I consider it so important that all of the world should read it," Odeh says. "This book caused me to think deeply about natural resources. Not just what's going on now, but preventive action."

While living in Berkeley, Odeh took a special interest in coursework about risk mitigation and found opportunities to apply those lessons to support water service providers in Palestine. Because water service providers have suffered disruptions, some Palestinian subscribers have stopped paying their bills. As a result, service providers have been unable to afford enough water to continue reliable service. ELP participants learned to identify the influence of each stakeholder in conflicts like these. Odeh took the lesson literally. Over the summer, he launched a social media campaign, using local influencers to explain the ripple effects of leaving water bills unpaid. According to Odeh, some service provider incomes have improved since conducting this exercise, bringing them closer to financial stability.

DECENTRALIZING NATURAL RESOURCES

Besides new skills, connections made at UC Berkeley have followed Odeh back home. He's currently collaborating on a research paper with UC Berkeley hydrology professor **Paolo D'Odorico** and environmental justice professor **Michael Mascarenhas** about water rights in Palestine. Odeh is offering firsthand expertise to complement an academic analysis and summary of the situation.

In addition to his work with water, Odeh has spent the last several years managing his own business. As an environmental and civil engineer, he develops and sells sustainable services, like biodigesters that turn organic waste into energy, hydroponic systems, and solar panels. The goal, he says, is to share tools that will empower Palestinians on their land despite the political challenges they face. "All of the solutions that I invest in are decentralized—at the household level, at the village level, and at the city level," Odeh says. "In case problems happen, you have your own sources of water, energy, and food. You can take them and survive."

Since participating in the ELP, Odeh says he's learned the difference between acting as a manager and serving as a true leader. It's about having the confidence to take initiative as an individual. "It starts with a lot of small behaviors. For example, when leaving a room, I turn off the light," Odeh says. "If I do that, and you do that, and one million people do that, we will make global change."

Courtesy of Ali Odeh

Ali Odeh and ELP guest John Gage during the summer 2024 program.

Empowering global scholars

DONOR-FUNDED FELLOWSHIPS ARE SUPPORTING GLOBAL SCHOLARS AND SOLUTIONS

BY MATHEW BURCIAGA

As one of the world's leading public universities, UC Berkeley receives tens of thousands of applications each year from students across the United States and overseas. Nearly 7,400 international students from 140 countries enrolled at Berkeley this past fall, making up 16% of the University's total student population.

"International students are vital to our College, as their unique insights and experiences deepen our collective understanding of global sustainability challenges," said **David Ackerly**, dean of Rausser College of Natural Resources. Despite their contributions and robust campus community, international students face a unique set of hurdles—visa requirements and restrictions, limited access to financial aid, and language and cultural differences—that make it difficult to pursue a Berkeley education.

Donor-funded initiatives can play an instrumental role in creating new opportunities for such students. Through the Swift International Fellowship, Rausser College has been able to recruit and retain international students who might otherwise be less likely to attend UC Berkeley's graduate programs.

"Pursuing a PhD at UC Berkeley has been a transformative experience for my personal growth and journey to be a proficient scientist and practitioner," said **Sheherazade**, a PhD candidate in the Department of Environmental Science, Policy, and Management, who paid her first two years of supplemental tuition with the fellowship. "This fellowship has allowed me to join a learning space where I feel seen, valued, respected, and supported." Originally from the Central Sulawesi province of Indonesia, Sheherazade is researching the effectiveness of conservation strategies in the Wallacea region—which includes her hometown of Palu—while seeking partnerships with relevant ministries, local universities, and conservation organizations.

Enrico Calvanese, a PhD candidate in the Department of Plant and Microbial Biology, received fellowship funding during the third year of his studies. Born in Italy and raised in Panama, Calvanese—who has an undergraduate background in biochemistry, molecular biology, and physics—works alongside Assistant Professor **Yangnan Gu** to study how nuclear membrane proteins could govern plant immunity and stress responses. Their findings may enhance the stability of global food networks.

For **María Villalpando Páez**, an Energy and Resources Group PhD candidate from Mexico City, fellowship funding has enabled her fieldwork in southern Mexico's High Mixtec Region. Conducted in collaboration with Mexico's National Autonomous University Geography Institute and UNESCO's Mixteca Alta Geopark, her research examines Mixtec peasant women's agrifood practices and how they contribute to equitable and healthy household food systems. Her findings highlight the women's ability to access, create, and disseminate their agricultural values and expertise. "The Fellowship was crucial to conducting long-term, in-person fieldwork—which I believe is necessary to deepen the scope and impact of critical food studies research," she said.

To support Rausser College's goal of cultivating a generation of leaders equipped to foster sustainability on an international scale, contact Andrew Judd at judd@berkeley.edu or visit nature.berkeley.edu/giving.

From left: Sheherazade, Enrico Calvanese, and María Villalpando Páez.

Mathew Burciaga (Sheherazade); Courtesy (Villalpando, Calvanese)

Biocultural Diversity

PHOTOGRAPH BY ROBINSON MANUEL RUZ SAMPAYO

A *People and Nature* study led by Assistant Professor **Alejandra Echeverri** uses biology, anthropology, music, and geography to map where biodiversity and cultural diversity overlap in Colombia, one of Earth's most biodiverse countries. The research highlights areas with the greatest potential for sustainable ecotourism and provides a planning framework that could be applied elsewhere. Pictured here is Melissa Cure, queen of Colombia's Carnival of Barranquilla in 2024, dressed as a jaguar—a symbol of power, strength, and spiritual connection for many Latin Americans of mestizo origins. Events like the Carnival showcase how wildlife is deeply embedded in cultures around the world.

SEE THE BIGGER PICTURE. MAKE A BETTER WORLD.
Support Rausser College of Natural Resources at nature.berkeley.edu/give.

UC Berkeley
Rausser College of
Natural Resources

101 Giannini Hall #3100
Berkeley, CA 94720-3100

NONPROFIT ORGANIZATION
US POSTAGE
PAID
UNIVERSITY OF CALIFORNIA
BERKELEY

Postdoctoral scholar Alexandra Kahn (left) and graduate student Monica Donegan used bacterial DNA from centuries-old grapevines to reconstruct the history of a disease plaguing wine country. Learn more on page 2.

Want to receive only the online version of *Breakthroughs*? Send your name, mail ID, and email address to breakthroughs@berkeley.edu.